Appendix A

Harmonia^{+PL} – procedure for negative impact risk assessment for invasive alien species and potentially invasive alien species in Poland

QUESTIONNAIRE

A0 | Context

Questions from this module identify the assessor and the biological, geographical & social context of the assessment.

a01. Name(s) of the assessor(s):

first name and family name

1. Wojciech Bielański – external expert
2. Grzegorz Cierlik – external expert
3. Wojciech Solarz

acomm01. Comments:

	degree	affiliation	assessment date
(1)	dr	Institute of Nature Conservation of the Polish Academy of Sciences in Cracow	15-12-2017
(2)	mgr	Institute of Nature Conservation of the Polish Academy of Sciences in Cracow	18-12-2017
(3)	dr	Institute of Nature Conservation of the Polish Academy of Sciences in Cracow	18-12-2017

a02. Name(s) of ***the species*** under assessment:

Polish name: Wrona orientalna

Latin name: ***Corvus splendens*** Vieillot, 1817

English name: House crow

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acomm02.	Comments:

Polish name (synonym I) –	Polish name (synonym II) –
Latin name (synonym I) –	Latin name (synonym II) –
English name (synonym I) Indian house crow	English name (synonym II) Gray-necked crow

a03. **Area** under assessment:

Poland

acomm03.	Comments: –

a04. **Status** of *the species* in Poland. *The species* is:

	native to Poland
	alien, absent from Poland
	alien, present in Poland only in cultivation or captivity
X	alien, present in Poland in the environment, not established
	alien, present in Poland in the environment, established

aconf01.	Answer provided with a	low	medium **X**	high	level of confidence

acomm04.	Comments: There is only one observation of a single individual, found on 29.04.2002 in southern Poland, in a gravel pit in Palczowice (Ottens and Ryall 2003 – P). The Avifaunistic Commission of the Ornithological Section of the Polish Zoological Society (KF 2018 – I) has classified this species into category E of non-native avifauna – species from captivity, as well as unintentionally introduced, which have not established self-supporting populations (unnatural occurence). Although there is a suggestion that an individual observed in Poland could be an escapee, the firm evidence is lacking (Ryall 2010 – P), and there are no known cases of such escapes of house crows to date (Fraser et al. 2015 – P).

a05. The impact of *the species* on major domains. *The species* may have an impact on:

X	the environmental domain
X	the cultivated plants domain
X	the domesticated animals domain
X	the human domain
X	the other domains

acomm05.	Comments: The species has a negative impact on all listed spheres. The impact on the natural environment and animal husbandry is manifested mainly through predation, harassment and disturbance of many wild and bred animal species, as well as through food and nest competition with other birds, and the risk of transmitting many pathogens and parasites of animals, including those causing incurable and fatal diseases, like avian influenza A H5N1 and A H5N8 viruses, Newcastle disease virus, *Salmonella* spp. and *Mycoplasma gallisepticum* (Parrott 2011 – P, CABI 2018 – B). In each location where they are numerous, house crows have a negative effect on plant cultivation, being a serious pest, plundering and destroying food and industrial crops, as well as already harvested food (Parrott 2011 – P, CABI 2018 – B). The impact on humans is associated with the potential risk of transmitting the AH5N1 virus of avian influenza, fatal to humans (Smith et al. 2009 – P), as well as a number of other dangerous zoonotic diseases. In addition, crows attacking passers-by were observed during breeding season, protecting their nests or offspring (Soh et al. 2002 – P),

	the species is sometimes also very burdensome, due to considerable noisiness, pollution of human living space, water and food with feces and waste, food theft, destruction of infrastructure (Jennings 1992, Brook et al. 2003, Puttoo and Archer 2003 – P, CABI 2018 – B).

A1 | Introduction

Questions from this module assess the risk for *the species* to overcome geographical barriers and – if applicable – subsequent barriers of captivity or cultivation. This leads to *introduction*, defined as the entry of *the organism* to within the limits of *the area* and subsequently into the wild.

a06. The probability for ***the species*** to expand into Poland's natural environments, **as a result of self-propelled expansion** after its earlier introduction outside of the Polish territory is:

X	low
	medium
	high

aconf02.	Answer provided with a	low	medium	high **X**	level of confidence

acomm06. Comments:

The species does not exist in countries neighboring Poland. Hungary is the closest country where the house crow was observed, with the single individual sighted in 2002 (Ottens and Ryall 2003 – P). The only European population of the species established in Hoek van Holland in the Netherlands is controlled and has been a subject of eradication campaign since 2014 (from ca. 35 individuals in 2015 only 5 remained, Ryall 2016 – P). This fact minimizes the risk of further spread of birds from this population in Europe.

a07. The probability for *the species* to be introduced into Poland's natural environments by **unintentional human actions** is:

X	low
	medium
	high

aconf03.	Answer provided with a	low	medium	high **X**	level of confidence

acomm07. Comments:

There has been only one record of the species so far in Poland in 2002 (Ottens and Ryall 2003 – P), which suggests that the probability of more than 1 record per decade is very low. Birds occurring in Europe most likely arrive here only on ships (Parrott 2011, Ryall 2016 – P). If populations such as the Dutch one would not undergo rapid intervention, this would increase the risk of further species colonization in European areas, including Poland. Maritime transport would enable such an introduction, with about 3 vessels a day arriving to Polish ports from the Netherlands, mainly from Rotterdam (2013-2016, GUS 2017 – P). For example, a single individual, observed in Ireland in 2010-2012 was suggested to arrive there on a ship and to originate from the Dutch population (Ryall 2016 – P). Also, the expected development of maritime transport, including contacts with Asian and African ports, where the species is numerous, poses a potential risk of its direct introduction into Poland.

a08. The probability for *the species* to be introduced into Poland's natural environments by **intentional human actions** is:

X	low
	medium
	high

aconf04.	Answer provided with a	low	medium	high **X**	level of confidence

acomm08. Comments:

Last intentional introductions of the species, in order to clean up refuse and biocontrol of pests and parasites (e.g. ticks and plagues of caterpillars from the *Spodoptera* genus) took place in the 19th century in Aden (present Yemen), Klang (present Port Klang in Malaysia), and Zanzibar (current Tanzania); the risk of continuing them is minimal today (Ryall 1994 – P, CABI 2018 – B). In Europe, including Poland, there are currently no reasons why the species could be deliberately introduced. There is no information concerning its presence in Polish zoos (Topola 2017 – P, Zootierliste 2018 – B) or other places of captivity, and it does not seem attractive to breeders of exotic animals. There are also no known cases of escapes of captive house crows (Fraser et al. 2015 – P). The likelihood of intentional introduction is therefore no greater than 1 case per decade.

A2 | Establishment

Questions from this module assess the likelihood for *the species* to overcome survival and reproduction barriers. This leads to *establishment*, defined as the growth of a population to sufficient levels such that natural extinction within *the area* becomes highly unlikely.

a09. Poland provides **climate** that is:

	non-optimal
X	sub-optimal
	optimal for establishment of *the species*

aconf05.	Answer provided with a	low	medium	high **X**	level of confidence

acomm09. Comments:

The species demonstrates great plasticity in terms of adaptation to various climatic conditions, therefore the appropriate climatic niche is probably not the most important factor determining its occurrence (Nyári et al. 2006, Parrot 2011 – P). Although the climate of Poland differs significantly from the climate in the natural range of the species (tropical or subtropical), it shows similarity to the climatic conditions of the Netherlands (according to Fig. 1 in the *Harmonia*+PL document – procedure of negative impact risk assessment for invasive and potentially invasive alien species in Poland), where house crows settled and bred, gradually increasing population size and regularly wintered for many years, even at temperatures down to -8°C (Ryall 2003 – P). An individual who survived at least 5 years was also observed in Ireland (Parrott 2011 – P). It should also be noted that there is a high probability of establishment occurring primarily in the Polish coastal belt (see a10). Maps of average and extreme winter temperatures in the subsequent years of the last decade indicate that the Polish coastal belt and the north-western part of the country have a climate that is moderately favorable to colonization and wintering for this species (2009-2017, IMGW 2018 – B), although there were winters with temperatures much lower than the lowest temperatures at which the birds survived in the Netherlands.

a10. Poland provides **habitat** that is

	non-optimal
	sub-optimal
X	optimal for establishment of *the species*

aconf06.	Answer provided with a	low	medium **X**	high	level of confidence

acomm10.	Comments:

The species' invasive potential, and the capacity of a wider spread in Europe are indicated (Nyári et al. 2006 – P). Both in its native and introduced range, the house crow is dependent on the presence of humans, human food and refuse. It is an omnivorous species which uses the most easily available food (CABI 2018 – B). The above characteristics increase its ability to establish in new areas (Nyári et al. 2006 – P). In fact, apart from the food abundance, the only ecological requirement of the species seems to be the presence of large trees, suitable for nesting and communal roosting (CABI 2018 – B).

The present species distribution demonstrates that the coastal areas, highly urbanized or with abundant human presence, e.g. attractive tourist places (Ryall 1994, 2010, 2016 – P), are most prone to establishment. Thus, places of the species' establishment in Poland would most likely be restricted to seaports, their surroundings and a narrow populated coastal belt. It seems that the most needed resources for the species (mainly food of human origin and wooded areas) are provided in many places of the Polish coast, therefore the habitat conditions would be favorable, and certainly they would not differ significantly from those present around the Dutch population (Ryall 2003 – P).

A3 | Spread

Questions from this module assess the risk of *the species* to overcoming dispersal barriers and (new) environmental barriers within Poland. This would lead to spread, in which vacant patches of suitable habitat become increasingly occupied from (an) already-established population(s) within Poland.

Note that spread is considered to be different from range expansions that stem from new introductions (covered by the Introduction module).

a11. The capacity of *the species* to disperse within Poland by natural means, **with no human assistance**, is:

	very low
	low
X	medium
	high
	very high

aconf07.	Answer provided with a	low	medium **X**	high	level of confidence

acomm11.	Comments:

Dispersion from a single source (Data type: A)
Within their natural range, house crows are usually sedentary, however they typically go on foraging trips of up to ca. 15 km (Ottens and Ryall 2003 – P). Based on data from the population in Hoek van Holland, the capacity of the species to disperse spontaneously from a single site should be assessed in Poland as medium (approx. 1.5 km/year). The Dutch population, founded by a single pair in 1994, began breeding in 1997, it increased to about 12 individuals in 2002, and only in 2003 a satellite colony with at least 4 individuals was established in Den Haag, about 15 km from the source population (Ottens and Ryall 2003 – P). These birds most likely originated from Hoek van Holland, whereas the other, more distant observations from different locations in the Netherlands were not associated with the main population and could be the result of independent introductions (Ottens and Ryall 2003 – P).

Population expansion (Data type: B)
Despite the fact that house crows most often inhabit urbanized coasts, they can spread further inland (e.g. along major roads), provided they have appropriate resources (Parrott 2011, Ryall 2010, 2016 – P). Such a probably slow dispersal from coastal to inland areas, would also be possible in Poland. The possibility of further movement of this species (most probably spontaneous or at least not ship-assisted), can be confirmed by observations of single individuals from 2002 in Poland and Hungary, both inland, far from the coastline

(Ottens and Ryall 2003 – P). There is however, no certainty as to the origin of these birds (assumed escapees, Ryall 2010 – P). There are significant differences in the management and utilization of municipal waste, slaughterhouse waste, etc. between Poland and e.g. developing African countries, where the dispersal rate of the species is high. It is also possible that the breeding output in Polish temperate climate will be lower than those achieved in the tropics and subtropics, as proved by observations e.g. in the Netherlands (Cramp 1994, Ryall 2003 – P). Having considered the foregoing, it may be suspected that the rate of house crow spread in Poland will be limited or slowed down by a smaller number of areas rich in food of anthropogenic origin, as well as slower reproduction.

a12. The frequency of the dispersal of *the species* within Poland by **human actions** is:

X	low
	medium
	high

aconf08.	Answer provided with a	low	medium	high **X**	level of confidence

acomm12. Comments:

The species spread by human actions is unlikely in Poland; the frequency of such dispersal would be low. In most cases, new introductions originate from ship-assisted transfer (Parrott 2011, Ryall 2016 – P). The spread of individuals from the populations already established in Poland (coastline mainly) could occur with the support of ships traveling between Polish ports. However, having analyzed the data on the Dutch population again, one should expect low incidence of such spread (no more than 1 case per decade). For example, an individual observed in Ireland between 2010 and 2012 is the only one suspected of originating from the Hoek van Holland population, existing since 1994 (Ryall 2016 – P).

A4a | Impact on the environmental domain

Questions from this module qualify the consequences of *the species* on wild animals and plants, habitats and ecosystems.

Impacts are linked to the conservation concern of targets. Native species that are of conservation concern refer to keystone species, protected and/or threatened species. See, for example, Red Lists, protected species lists, or Annex II of the 92/43/EWG Directive. Ecosystems that are of conservation concern refer to natural systems that are the habitat of many threatened species. These include natural forests, dry grasslands, natural rock outcrops, sand dunes, heathlands, peat bogs, marshes, rivers & ponds that have natural banks, and estuaries (Annex I of the 92/43/EWG Directive).

Native species population declines are considered at a local scale: limited decline is considered as a (mere) drop in numbers; severe decline is considered as (near) extinction. Similarly, limited ecosystem change is considered as transient and easily reversible; severe change is considered as persistent and hardly reversible.

a13. The effect of *the species* on native species, through **predation, parasitism or herbivory is**:

	inapplicable
	low
	medium
X	high

aconf09.	Answer provided with a	low	medium **X**	high	level of confidence

acomm13. Comments:

The house crow influences other animals through predation. It feeds on eggs, chicks and adult wild birds, other smaller vertebrates and invertebrates. As an omnivorous species, it

also feeds on plants, but its negative impact on any plant species has not yet been demonstrated (CABI 2018 – B). Both in its native and introduced range, wherever there has been a significant increase in population number, the negative impact on native birds is often serious. For example, in Mombasa and its surroundings (Kenya), the house crow predation on 13 bird species has been observed (Ryall 1992 – P). Colonial birds, such as weavers *Ploceidae* or herons *Ardeidae* were particularly vulnerable, but solitary nesters were also predated. Dramatic declines in numbers of further species have been related to the increase of crow population, yet predation was not confirmed (Ryall 1992, Puttoo and Archer 2003 – P). In the Netherlands, there are important colonies of common tern *Sterna hirundo* and pied avocet *Recurvirostra avosetta* within 8 km of Hoek van Holland population, but to date no crows have been observed in the vicinity of these colonies (Ryall 2003 – P). If the development of this population was not stopped, a negative impact would probably be noticeable.

The list of native species on which the house crow could exert significant impact through predation is very long, and it is impossible to cite them all. Assuming a likely scenario in which the species would expand from the coast, and considering that the introduced populations do not usually spread further than tens of kilometers from the shoreline (except for the populations in Kenya and Tanzania, quickly spreading inland along major roads, Ryall 2010, 2016 – P), one can suspect that the following birds nesting in the Polish coastal belt would be the most vulnerable to predation of the house crow: colonial terns and gulls, waders, raptors, anatids, grebes and storks. Almost all species from these groups are subject to strict protection in Poland under the regulation of the Minister of the Environment of 16th December 2016 on species protection of animals, many are included in Annex I of the Birds Directive (DP 2009 – P) and in the Polish Red Data Book of Animals (Głowaciński 2001 - P). The effect of house crow predation on populations of native birds, such as the sandwich tern *Sterna sandvicensis*, with a single breeding colony in Poland, could be catastrophic. Similarly, in case of plundering even single brood of western osprey *Pandion haliaetus*, golden eagle *Aquila chrysaetos*, common shelduck *Tadorna tadorna*, Eurasian oystercatcher *Haematopus ostralegus,* common ringed plover *Charadrius hiaticula* or Eurasian curlew *Numenius arquata* – extremely rare breeding birds in Poland, the effect on their native populations would be critical. Sea mammals, including the grey seal *Halichoerus grypus* and harbour porpoise *Phocoena phocoena*, could potentially be vulnerable to crow attacks on sea beaches. If the house crow spread would occur across Poland, one would expect its greatest predatory pressure on typical, mostly common species of urban and suburban ecosystems. However, the urban population of the extremely rare peregrine falcon *Falco peregrinus* (listed in Annex I of the Birds Directive: DP 2009 – P and in the Polish Red Data Book of Animals: Głowaciński 2001 – P) would also be at risk, similarly the common kestrel *Falco tinnunculus* (strict protection), with the majority of the Polish population of this species located in cities. In the surroundings of urbanized areas (even within 10 km radius, Ryall 1992 – P), birds of open habitats (e.g. northern lapwing, grey partridge, common quail – all demonstrating downward trends in Poland) would be particularly susceptible to predation (Chodkiewicz et al. 2016 – P), including all species with more exposed nests, such as raptors, storks, corvids, pigeons and numerous passerines. Species of special care from natural areas, directly adjacent to urban areas, would also be potentially exposed to predation. Nevertheless, in the native range in India, the house crow, although very common in many cities, does not penetrate intact forest or other unpopulated areas (CABI 2018 – B). Rare mammals that could potentially be at risk of the house crow predation include such species as spotted souslik *Spermophilus suslicus*, European ground squirrel *Spermophilus citellus* and European hamster *Cricetus cricetus* – all protected by Polish law (strict protection) and EU law (Annex IV of the Habitat Directive: DS 1992 – P). One may suspect that protected and rare reptiles and amphibians would also be preyed upon, especially in the vicinity of their breeding sites. If the house crow increases in numbers and spread significantly in Poland, the lack of preferred habitats/sufficient number of places rich in food of human origin (see a11) may intensify its negative impact on native species through predation.

a14. The effect of *the species* on native species, through **competition** is:

	low
	medium
X	high

aconf10.	Answer provided with a	low	medium **X**	high	level of confidence

acomm14. Comments:

It has been proven that the house crow can compete with native bird species. Its large aggression, kleptoparasitism, harassment and disturbance cause displacement or significant decline in numbers of other avian species (Ryall 1992, Cramp 1994, Brook et al. 2003, Puttoo and Archer 2003 – P). In urban areas of its introduced range, the house crow competition is often manifested in displacing other bird species using anthropogenic food (Ryall 1992 – P). Also in Poland, food and nest competition would most likely affect other birds inhabiting urban areas, mainly the hooded crow *Corvus cornix*, which occupies almost identical ecological niche in cities, as well as the rook *Corvus frugilegus*, western jackdaw *Corvus monedula*, several species of gulls *Laridae*, rock pigeon *Columba livia*, common wood pigeon *Columba palumbus*, Eurasian collared dove *Streptopelia decaocto*, house sparrow *Passer domesticus*. Impacts on the hooded crow, rook and sparrow could be significant and intensify their long-term downward trend in Poland (Chodkiewicz et al. 2016 – P). The house crow competitive behavior and harassment would probably affect a number of further species from urban/suburban areas. In addition to the effect on breeding species, food competition with wintering birds would be expected. Small negative impact on special care species from nature protection areas, located in the immediate vicinity of urban areas, would also be potentially possible. Nevertheless, in the native range in India, the house crow, although very common in many cities, does not penetrate intact forest or other unpopulated areas (CABI 2018 – B).

a15. The effect of *the species* on native species, through **interbreeding** is:

X	no / very low
	low
	medium
	high
	very high

aconf11.	Answer provided with a	low	medium	high **X**	level of confidence

acomm15. Comments:

There are no known cases of interbreeding of the house crow with other species, both in its natural range and in the areas of introduction.

a16. The effect of *the species* on native species by **hosting pathogens or parasites** that are harmful to them is:

	very low
	low
	medium
	high
X	very high

aconf12.	Answer provided with a	low	medium	high **X**	level of confidence

acomm16. Comments:

There are approx. 30 different pathogens and parasites detected in *Corvus splendens* (Najberek, in prep. – N). These include viruses, bacteria, fungi, protozoa, helminths, nematodes and acanthocephalans. The most dangerous ones, listed by the World

Organization for Animal Health (OIE) include: highly pathogenic avian influenza A H5N1 and A H5N8 viruses (Smith et al. 2009, Nagarajan et al. 2017 – P), causing high mortality among wild and domestic birds (all bird species are susceptible to them); PMV 1 paramyxovirus (Roy et al. 1998 – P), causing highly deadly Newcastle disease, also present in wild birds; *Salmonella* spp. (Al-Sallami 1991, Jennings 1992 – P), causing salmonellosis in various groups of wild animals, and in case of birds, additionally: fowl typhoid and pullorum disease; infections with certain *Salmonella* serovars can be uncurable and lead to death; bacteria *Mycoplasma gallisepticum* (Ganapathy et al. 2007 – P), causing mycoplasmosis in birds, including wild birds (e.g. pigeons, galliforms, ducks, geese), a serious systemic infection that can even lead to death. It is also believed that, like other corvids, *C. splendens* can potentially act as a reservoir of West Nile virus (Nyári et al. 2006 – P), causing severe, often fatal disease mainly in wild birds (especially in corvids *Corvidae* and geese *Anserinae*, OIE 2018 – I). Other pathogens and parasites, not listed by the OIE, but which have been found in the house crow and which this species is likely to transfer to wild native species, include: the fungal species *Cryptococcus neoformans* (Gokulshankar et al. 2004 – P), causing severe cryptococcosis in wild animals, including birds; a blood parasite *Trypanosoma corvi* found in the house crow (Stephens and Christophers 1908 – P), but the known hosts of this parasite in Europe include the rook, western jackdaw, *Turdus* family, and most likely numerous other species, not only from the *Corvidae* family (Votypka et al. 2004 – P). House crows mainly inhabit cities and populated suburban areas, therefore the transmission of parasites and diseases to common native species from these areas is most likely.

a17. The effect of *the species* on ecosystem integrity, by **affecting its abiotic properties** is:

X	low
	medium
	high

aconf13. Answer provided with a

low	medium	high
	X	

level of confidence

acomm17. Comments:

The negative effect of this species on ecosystem integrity, both within its natural range and in the introduction areas has not been described so far. Significant faecal deposition may potentially increase habitat fertility and eutrophication of waters in places of high crow density; this, in turn, may affect changes in the composition and/or succession of plant communities and the functioning of organisms within the ecosystem. However, the consequence on ecosystem integrity caused by these processes is estimated to be low.

a18. The effect of *the species* on ecosystem integrity, by **affecting its biotic properties** is:

	low
X	medium
	high

aconf14. Answer provided with a

low	medium	high
	X	

level of confidence

acomm18. Comments:

It is suspected that through the house crow predation and decrease of food resources, harassment, disturbance and aggression towards other species (mainly birds), populations of these species will decrease in places of increased crow pressure. This in turn may lead to trophic cascade, e.g. withdrawal of raptors, corvids, increase in the number of certain invertebrate populations, etc. The foregoing effect has not been recognized so far both in native and introduced range of the species. However, it would most likely concern habitats which are not special care ones (urban/suburban areas) or changes in processes occurring in special care habitats would be easily reversible (medium effect).

A4b | Impact on the cultivated plants domain

Questions from this module qualify the consequences of *the species* for cultivated plants (e.g. crops, pastures, horticultural stock).

For the questions from this module, consequence is considered 'low' when presence of *the species* in (or on) a population of target plants is sporadic and/or causes little damage. Harm is considered 'medium' when *the organism's* development causes local yield (or plant) losses below 20%, and 'high' when losses range >20%.

a19. The effect of *the species* on cultivated plant targets through **herbivory or parasitism** is:

	inapplicable
	very low
	low
	medium
X	high
	very high

aconf15.	Answer provided with a	low	medium **X**	high	level of confidence

acomm19. Comments:

In many Asian and African countries, where the house crow is abundant, it is regarded as a serious pest, plundering and destroying many crops, such as wheat, maize, oats, sorghum, sunflower, legumes and various fruits. It also feeds on already harvested food and industrial crops (Parrot 2011 – P, CABI 2018 – B). Losses in wheat and maize, amounting to 55% and 81% of yields respectively (Dhindsa and Saini 1994, Reddy 1998 - P) were recorded in India. Similarly, in Polish conditions, the negative effect would probably affect cereal, vegetable and fruit crops, and the area of the species' impact would mainly include cities, suburban areas, and potential rural areas in the immediate vicinity of cities. It is predicted that if the species spread throughout Poland, the local effect will affect 1/3 to 2/3 of crops subject to invasion (medium probability), and the condition or yield of a single crop could be reduced by over 20% (large effect).

a20. The effect of *the species* on cultivated plant targets through **competition** is:

X	inapplicable
	very low
	low
	medium
	high
	very high

aconf16.	Answer provided with a	low	medium	high	level of confidence

acomm20. Comments:

The species is not a plant.

a21. The effect of *the species* on cultivated plant targets through **interbreeding** with related species, including the plants themselves is:

X	inapplicable
	no / very low
	low
	medium
	high
	very high

aconf17.	Answer provided with a	low	medium	high	level of confidence

acomm21. Comments:

The species is not a plant.

a22. The effect of *the species* on cultivated plant targets by **affecting the cultivation system's integrity** is:

- [X] very low
- [ ] low
- [ ] medium
- [ ] high
- [ ] very high

aconf18.	Answer provided with a	low	medium **X**	high	level of confidence

acomm22. Comments:

Changes in the trophic network caused by the species (see a18) may also potentially lead to disturbance of crop integrity (e.g. reduction of populations of insectivorous birds, which may enhance the development of crop pests). However, this type of the house crow effect on plant cultivation has not yet been demonstrated. With much greater human interference in the functioning of agroecosystems, it is estimated that the influence of the house crow on the integrity of crops, if observed at all, will be very small (low probability, low consequence).

a23. The effect of *the species* on cultivated plant targets by hosting **pathogens or parasites** that are harmful to them is:

- [X] very low
- [ ] low
- [ ] medium
- [ ] high
- [ ] very high

aconf19.	Answer provided with a	low	medium	high **X**	level of confidence

acomm23. Comments:

In case of the house crow, no transmission of pathogens or parasites harmful to crops has been found so far.

A4c | Impact on the domesticated animals domain

Questions from this module qualify the consequences of *the organism* on domesticated animals (e.g. production animals, companion animals). It deals with both the well-being of individual animals and the productivity of animal populations.

a24. The effect of *the species* on individual animal health or animal production, through **predation or parasitism** is:

- [ ] inapplicable
- [ ] very low
- [ ] low
- [ ] medium
- [ ] high
- [X] very high

aconf20.	Answer provided with a	low	medium	high **X**	level of confidence

acomm24. Comments:

Both in its natural range and the introduction areas, the species often exerts significant negative impact on livestock, domestic animals and animal production (Parrot 2011 – P). The house crow feeds on eggs and poultry chicks, and the free range poultry is particularly vulnerable to predation (Puttoo and Archer 2003 – P). The species can also kill young individuals of other domesticated animals, e.g. sheep and goats, and even injure the adult individuals (Cramp 1994, Puttoo and Archer 2003 – P). It is also believed that predation can potentially exert negative impact on a number of game birds (Parrot 2011 – P). Having considered the habitat preferences of the species and assuming its spread throughout the country, one can suspect that predation concerning domesticated animals will usually be limited to urban, suburban and potentially rural areas in the immediate vicinity of cities. Crows, like other omnivorous corvids, adapt very quickly to utilizing the most easily available, abundant food. Because of that, attacks on animals may occur more frequently in areas with low food waste availability. The likelihood of predation is estimated to be high, and its consequence – to be high.

a25. The effect of *the species* on individual animal health or animal production, by having properties that are hazardous upon **contact**, is:

	very low
	low
X	medium
	high
	very high

aconf21.	Answer provided with a	low	medium **X**	high	level of confidence

acomm25. Comments:

It is known that house crows are aggressive towards other animals, especially when competing for food. Instances of harassment and disturbance, attacks and injuries to domesticated and farm animals have been observed (Jennings 1992, Puttoo and Archer 2003, Parrot 2011 – P, CABI 2018 – B). Such behavior may adversely affect the health and condition of domestic and farm animals, as well as animal production. The probability of such a consequence is estimated to be medium, similar to its result.

a26. The effect of *the species* on individual animal health or animal production, by hosting **pathogens or parasites** that are harmful to them, is:

	inapplicable
	very low
	low
	medium
	high
X	very high

aconf22.	Answer provided with a	low	medium	high **X**	level of confidence

acomm26. Comments:

A number of pathogens, parasites and pathogenic agents of animals have been detected in *Corvus splendens* (see a16 and Najberek, in prep. – N). Most of them are capable of causing diseases in domesticated and farm animals. The most dangerous, listed by the World Organization for Animal Health (OIE) include: highly pathogenic avian influenza A H5N1 and A H5N8 viruses (Smith et al. 2009, Nagarajan et al. 2017 – P), causing high mortality among breeding birds; PMV 1 paramyxovirus (Roy et al. 1998 – P), causing highly deadly Newcastle

	disease; *Salmonella* spp. (Al-Sallami 1991, Jennings 1992 – P), causing salmonellosis in various groups of breeding animals, and in case of birds also: fowl typhoid and pullorum disease; infections with certain *Salmonella* serovars can be incurable and lead to death; bacteria *Mycoplasma gallisepticum* (Ganapathy et al. 2007 – P), causing mycoplasmosis in poultry (especially in chickens and turkeys), a serious systemic infection that can even lead to death. It is also believed that, like other corvids, *C. splendens* can potentially act as a reservoir of West Nile virus (Nyári et al. 2006 - P), causing severe, often fatal disease, most often in horses and birds, including poultry (e.g. geese, OIE 2018 – I). Further dangerous pathogens and parasites, not listed by the OIE, but found in the house crow, and which it is likely to transfer to domesticated animals, include: the fungal species *Cryptococcus neoformans* (Gokulshankar et al. 2004 - P), causing severe cryptococcosis, most commonly in cats and dogs, as well as in cattle, sheep, goats and horses; a number of pathogens causing acute gastrointestinal infections, including *Campylobacter* sp., *Escherichia coli*, *Giardia lamblia*, *Proteus* sp., *Plesiomonas* sp., *Aeromonas hydrophila* (Al-Sallami 1991 - P, Najberek, in prep. – N); protozoan *Toxoplasma gondii* (Salant et al. 2013 – P) causing toxoplasmosis, widespread in animals.

A4d | Impact on the human domain

Questions from this module qualify the consequences of *the organism* on humans. It deals with human health, being defined as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (definition adopted from the World Health Organization).

a27. The effect of *the species* on human health through **parasitism** is:

X	inapplicable
	very low
	low
	medium
	high
	vert high

aconf23.	Answer provided with a	low	medium	high	level of confidence

acomm27.	Comments: The species is not a parasite.

a28. The effect of *the species* on human health, by having properties that are hazardous upon **contact**, is:

	very low
	low
X	medium
	high
	very high

aconf24.	Answer provided with a	low	medium **X**	high	level of confidence

acomm28.	Comments: Increased aggression and attacks of nesting house crows on passers-by were observed in Asia (Soh et al. 2002 – P). People can potentially sustain injuries during such attacks. The probability of such contacts in Poland is estimated to be medium, and their consequence was considered as medium.

a29. The effect of *the species* on human health, by hosting **pathogens or parasites** that are harmful to humans, is:

	inapplicable
	very low
	low
	medium
	high
X	very high

aconf25.	Answer provided with a	low	medium	high **X**	level of confidence

acomm29. Comments:

There has been a number of parasites and pathogens detected in the house crow which can be transmitted to humans and cause diseases. The most dangerous ones include: highly pathogenic avian influenza viruses – the A H5N1 strain, which is lethal to humans (Smith et al. 2009 – P), and the A H5N8 strain (Nagarajan et al. 2017 – P) which causes high morbidity and mortality in poultry, but can also pose a lethal threat to humans (WHO 2016 – I); bacteria *Salmonella* spp. (Al-Sallami 1991, Jennings 1992 – P), causing human salmonellosis and typhoid fever; the fungal species *Cryptococcus neoformans* (Gokulshankar et al. 2004 – P), which causes dangerous and often fatal cryptococcosis. In addition, house crows have been shown to be a vector of many pathogens that cause severe gastrointestinal infections in humans, including *Campylobacter* sp., *Shigella* sp., *Plesiomonas* sp., *Escherichia coli*, *Giardia lamblia*, *Toxoplasma gondii*, *Proteus* sp., *Aeromonas hydrophila* (Al-Sallami 1991, Jennings 1992 – P, Najberek, in prep. – N). It is also believed that, like other corvids, *C. splendens* can potentially act as a reservoir of West Nile virus (Nyári et al. 2006 – P), inducing a dangerous, yet rarely fatal disease in humans (OIE 2018 – I). In addition to direct contact with other animals and people, the behavior of these birds, their food preferences, and foraging strategies – which often contributes to water and food pollution (including pollution with feces) – all promote disease transmission (Jennings 1992 – P, CABI 2018 – B).

A4e | Impact on other domains

Questions from this module qualify the consequences of *the species* on targets not considered in modules A4a-d.

a30. The effect of *the species* on causing damage to **infrastructure** is:

	very low
X	low
	medium
	high
	very high

aconf26.	Answer provided with a	low	medium **X**	high	level of confidence

acomm30. Comments:

The house crow often forms very large communal roosts, involving thousands of individuals (Cramp 1994, Soh et al. 2002 – P). In the vicinity of roosts and nest sites it causes serious pollution with feces and food scraps on buildings, streets, cars, sidewalks, paths, properties, park infrastructure, etc. Moreover, it can damage cables and TV antennas on the buildings, whereas its foraging at and near airports introduces a threat of collision with airplanes (Jennings 1992, Brook et al. 2003, Puttoo and Archer 2003, Meier and Ryall 2007 – P, CABI 2018 – B). Although there is no data on the effect on infrastructure in the surrounding of the only European population in Hoek van Holland, it should be assumed that in Poland, after the spread of the species throughout the country, this effect will be visible and burdensome. Its frequency was estimated to be medium and the consequence as low.

A5a | Impact on ecosystem services

Questions from this module qualify the consequences of *the organism* on ecosystem services. Ecosystem services are classified according to the Common International Classification of Ecosystem Services, which also includes many examples (CICES Version 4.3). Note that the answers to these questions are not used in the calculation of the overall risk score (which deals with ecosystems in a different way), but can be considered when decisions are made about management of *the species*.

a31. The effect of *the species* on **provisioning services** is:

X	significantly negative
	moderately negative
	neutral
	moderately positive
	significantly positive

aconf27.	Answer provided with a	low	medium	high **X**	level of confidence

acomm31. Comments:

House crows can cause serious damage and economic losses in both plant and animal production. The species destroys and plunders numerous crops and harvested food (see a19). These birds eat eggs, chicks, and even adult poultry, as well as injure and kill young individuals of other domesticated animals (see a24). Negative effects on the provisioning services may potentially also include the disturbance caused by the species in the agroecosystem function, e.g. changes in food webs (see a18 and a22), as well as aggression, harassment and injury to animals that adversely affect animal production (see a25). The species can foul drinking water and food (Jennings 1992 – P, CABI 2018 – B), and a number of animal diseases transmitted by it (including the most dangerous ones: avian influenza, Newcastle disease, salmonellosis, fowl typhoid, pullorum disease, mycoplasmosis, cryptococcosis; see a26) may create epidemiological risks and large losses in livestock production.

a32. The effect of *the species* on **regulation and maintenance services** is:

	significantly negative
X	moderately negative
	neutral
	moderately positive
	significantly positive

aconf28.	Answer provided with a	low	medium **X**	high	level of confidence

acomm32. Comments:

The effect on regulatory services was defined as moderately negative, due to the fact that the species may demonstrate negative impact on the regulation of zoonotic diseases through transmission of numerous serious diseases (mainly including A H5N1 and A H5N8 avian influenza viruses and Newcastle disease virus). The impact may also be negative on the pollution regulation and self-cleaning, through water and soil contamination with feces. The effect on biological regulation through predation on pests and other species which are undesirable from human perspective can be assessed as neutral, as house crows themselves often act as pests.

a33. The effect of *the species* on **cultural services** is:

	significantly negative
X	moderately negative
	neutral

	moderately positive
	significantly positive

aconf29.	Answer provided with a	low	medium **X**	high	level of confidence

acomm33. Comments:

In its native and introduced range the species is widely perceived as a serious pest and a threat to human health (CABI 2018 – B). The negative public reception is also influenced by: considerable noisiness, especially in the vicinity of large roosts and breeding places, pollution of the human living space (both with food scraps and feces), food thefts, attacks on passers-by and soiling them with droppings, destruction of infrastructure. Tourists often complain about disturbance and nuisance caused by the species (Jennings 1992, Brook et al. 2003, Puttoo and Archer 2003 – P, CABI 2018 – B). As a new, alien species in Poland, initially after its introduction, the house crow may be a great attraction for bird and nature watchers, as observed e.g. in case of the Dutch population (Ryall 2016 – P). Nevertheless, provided that a significant spread in the country would occur, the social attitude toward this species would most likely change to negative.

A5b | Effect of climate change on the risk assessment of the negative impact of *the species*

Below, each of the Harmonia^{+PL} modules is revisited under the premise of the future climate. The proposed time horizon is the mid-21st century. We suggest taking into account the reports of the Intergovernmental Panel on Climate Change. Specifically, the expected changes in atmospheric variables listed in its 2013 report on the physical science basis may be used for this purpose. The global temperature is expected to rise by 1 to 2°C by 2046-2065.

Note that the answers to these questions are not used in the calculation of the overall risk score, but can be but can be considered when decisions are made about management of *the species*.

a34. INTRODUCTION – Due to climate change, the probability for *the species* to overcome geographical barriers and – if applicable – subsequent barriers of captivity or cultivation in Poland will:

	decrease significantly
	decrease moderately
X	not change
	increase moderately
	increase significantly

aconf30.	Answer provided with a	low	medium	high **X**	level of confidence

acomm34. Comments:

Expected climate change (warming) most likely will not provide the species with capability of overcoming geographical barriers. It demonstrates high ecological plasticity, including the adaptability to various climatic conditions. It is believed that this adaptation is possible due to almost complete dependence of the species' survival on humans which also applies to the main dispersal pathways of the birds outside the native range (i.e. passively, on ships, Nyári et al. 2006, Parrot 2011 – P). Despite its origins from the tropics and subtropics, it has shown rapid expansion in the temperate climate of Europe. Introductions occurred repeatedly in the Netherlands, Denmark, Ireland and the United Kingdom – countries with climate similar to the one in Poland (Ryall 2016 – P, CABI 2018 – B).

a35. ESTABLISHMENT – Due to climate change, the probability for *the species* to overcome barriers that have prevented its survival and reproduction in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf31.	Answer provided with a	low	medium **X**	high	level of confidence

acomm35. Comments:

Global warming can increase the establishment of the species in Poland. It is suspected that the process of establishment will be accelerated due to the milder conditions for overwintering, the possibility of earlier breeding, greater breeding efficiency, and even the ability to have two clutches a year (as recorded e.g. in Kenya, Cramp 1994 – P). The significant climate role in terms of the breeding success is indicated by significantly lower breeding success in the Dutch population, compared to the natural range of the species in the tropics (Cramp 1994, Ryall 2003 – P). However, attention should be paid to the fact that urbanized areas, preferred by house crows, constitute "heat islands" themselves, creating more favorable conditions for wintering and reproduction. This aspect may reduce the effect of expected climate change on the probability of overcoming the establishment barrier, therefore it was estimated that this probability will increase moderately.

a36. SPREAD – Due to climate change, the probability for *the species* to overcome barriers that have prevented its spread in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf32.	Answer provided with a	low	medium **X**	high	level of confidence

acomm36. Comments:

Global warming can result in higher breeding success, rapid population development and dispersal of individuals to new areas (see a35). It seems, however, that in a species with such strong dependence on humans, the effect of climate change may not be the key factor for achieving the ability to spread (Nyári et al., 2006, Parrot 2011 – P). It has been assessed that due to climate change the probability of overcoming barriers allowing the house crow spread in Poland will increase moderately.

a37. IMPACT ON THE ENVIRONMENTAL DOMAIN – Due to climate change, the consequences of *the species* on wild animals and plants, habitats and ecosystems in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf33.	Answer provided with a	low	medium **X**	high	level of confidence

acomm37. Comments:

If, due to climate change, the likelihood of the species spread will increase (see a36), its negative effect on the natural environment (described in a13-a18) may also increase. In addition, the increase in temperature may demonstrate a positive effect on the survival, development and rate of spread of many pathogens and parasites of animals which are

transmitted by house crows and originate from a warmer climate (e.g. West Nile virus or *Trypanosoma corvi*). It has been determined that due to climate change, the species' effect on wild plants and animals, as well as habitats and ecosystems in Poland, will increase moderately.

a38. IMPACT ON THE CULTIVATED PLANTS DOMAIN – Due to climate change, the consequences of *the species* on cultivated plants and plant domain in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf34.	Answer provided with a	low	medium **X**	high	level of confidence

acomm38. Comments:

If, due to climate change, the likelihood of the species spread increases (see a36), its negative effect on plant cultivation (described in a19-a22) will probably also increase.

a39. IMPACT ON THE DOMESTICATED ANIMALS DOMAIN – Due to climate change, the consequences of *the species* on domesticated animals and animal production in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf35.	Answer provided with a	low	medium **X**	high	level of confidence

acomm39. Comments:

If the likelihood of the species spread increases due to climate change (see a36), its negative effect on the animal husbandry (described in a24-a26) will probably also increase. In addition, the temperature rise may show positive effect on the survival, development and rate of spread of many pathogens and parasites of animals which are transmitted by house crows and originate from a warmer climate (e.g. West Nile virus or *Trypanosoma corvi*). It has been determined that due to climate change, the effect of the species on animal breeding in Poland will increase moderately.

a40. IMPACT ON THE HUMAN DOMAIN – Due to climate change, the consequences of *the species* on human in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf36.	Answer provided with a	low	medium **X**	high	level of confidence

acomm40. Comments:

Provided that the likelihood of the species spread will increase due to climate change (see a36), its negative effect on humans (described in a28-a29) will probably also increase. In addition, the increase in temperature may have positive effect on the survival, development and rate of spread of many human pathogens and parasites transmitted by house crows and originating from a warmer climate (e.g. West Nile virus). It has been

	determined that due to climate change, the effect of the species on humans will increase moderately in Poland.

a41. IMPACT ON OTHER DOMAINS – Due to climate change, the consequences of *the species* on other domains in Poland will:

	decrease significantly
	decrease moderately
	not change
X	increase moderately
	increase significantly

aconf37.	Answer provided with a	low	medium **X**	high	level of confidence

acomm41.	Comments: Provided that the likelihood of the species spread will increase due to climate change (see a36), its negative effect on other objects (as described in item a30) will probably also increase.

Summary

Module	Score	Confidence
Introduction (questions: a06-a08)	0.00	1.00
Establishment (questions: a09-a10)	0.75	0.75
Spread (questions: a11-a12)	0.25	0.75
Environmental impact (questions: a13-a18)	0.58	0.67
Cultivated plants impact (questions: a19-a23)	0.25	0.67
Domesticated animals impact (questions: a24-a26)	0.83	0.83
Human impact (questions: a27-a29)	0.75	0.75
Other impact (questions: a30)	0.25	0.50
Invasion (questions: a06-a12)	0.33	0.83
Impact (questions: a13-a30)	0.83	0.68
Overall risk score	0.28	
Category of invasiveness	very invasive alien species	

A6 | Comments

This assessment is based on information available at the time of its completion. It has to be taken into account. However, that biological invasions are, by definition, very dynamic and unpredictable. This unpredictability includes assessing the consequences of introductions of new alien species and detecting their negative impact. As a result, the assessment of the species may change in time. For this reason it is recommended that it regularly repeated.

acomm42.	Comments: The house crow is a sedentary species, which significantly reduces its potential for independent expansion in Europe. The risk associated with the species invasion process in Poland has been assessed as low (value: 0.33) indicating a relatively low threat of introduction, establishment and spreading. Despite the low likelihood of introduction (questions: a06-a08), Poland shows favorable conditions with regard to species establishment (questions: a09-a10). The species confirmed its ability to establish in similar conditions in the Netherlands. It has been estimated that after introduction, the species would spread at a medium rate in Poland, predominantly (or only) spontaneously (questions: a11-a12). With regard to modules concerning the negative effect, the species was given the value of 0.83, indicating an real threat of the exerted effect. This is the reasons for its inclusion in the category of highly invasive alien species. The overall assessment of the negative effect consists mainly of high effect values on animal husbandry (0.83), people (0.75), and the natural environment (0.58). With regard to the modules: effect on the natural environment, and animal husbandry, high evaluation values are mainly determined by large risk of predation, disturbance, competition and the transmission of pathogens or parasites to other animal species. The combined evaluation of the impact on humans is influenced primarily by the high pathogen and parasite transmission risk. Nevertheless, it is important to note that the negative effect exerted on local avifauna through predation, aggression, and competition, as confirmed both in native and introduced range of the house crow, is considered to be the greatest potential threat from the species in Europe (Parrott 2011 - P).

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